

Keck Spectroscopy of Dwarf Elliptical Galaxies in the Virgo Cluster

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Keck spectroscopy is presented for four dwarf elliptical galaxies in the Virgo Cluster. At this distance, the mean velocity and velocity dispersion are well resolved as a function of radius between 100 to 1000 pc, allowing a clear separation between nuclear and surrounding galaxy light. We find a variety of dispersion profiles for the inner regions of these objects, and show that none of these galaxies is rotationally flattened.

1 Introduction

Dwarf elliptical galaxies (dEs) are among the poorest studied galaxies due to their faint luminosities, $M_V \gtrsim -17$, and characteristic low effective surface brightness $\mu_e(V) > 22 \text{ mag arcsec}^{-2}$ (Ferguson & Binggeli 1994). The defining characteristic of dEs is an exponential surface brightness profile. The majority of dEs brighter than $M_V = -16$ have compact nuclei typically containing 5 to 20% of the total galaxy light; most dEs fainter than $M_V = -12$ show no sign of a nucleus (Sandage *et al.* 1985). Although the sample of dEs with measured internal kinematics is small (Bender & Nieto 1990; Peterson & Caldwell 1993), these observations have provided strong evidence that dwarf and classical ellipticals evolve via very different physical processes.

Here we present Keck spectroscopy for four Virgo dEs. Velocity and velocity dispersion profiles are measured out to $\sim 1 \text{ kpc}$, assuming a Virgo Cluster distance of 16.1 Mpc (Kelson *et al.* 2000). These are the initial results of a larger project to study the dynamics of dwarf elliptical galaxies.

2 Keck Observations

Four Virgo dEs were observed with the Echelle Spectrograph and Imager (ESI) on the Keck II telescope in March 2001. The spectra were obtained through a

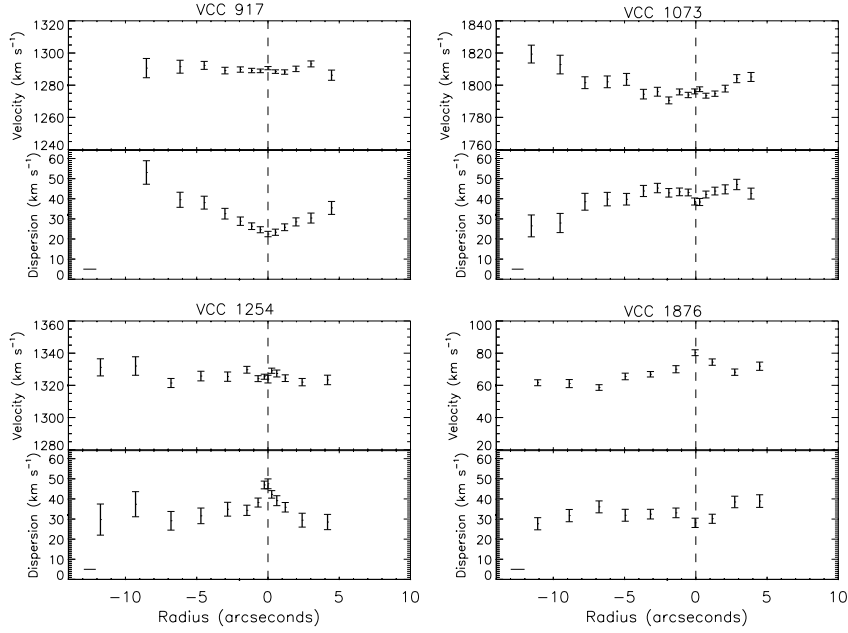


Figure 1: Mean velocity and velocity dispersion profiles for four Virgo dEs. The bar at the lower left of each panel indicates the seeing FWHM during each observation. At the distance of the Virgo Cluster, $1'' \sim 100$ pc.

$0.75'' \times 20''$ slit placed along the major axis of each galaxy with wavelength coverage $\lambda\lambda 3900-9500\text{\AA}$ and resolution of 23 km s^{-1} (Gaussian sigma). As shown in Table 1, the observed galaxies cover a range of ellipticities and three of the four are nucleated dwarfs (dE,N). These objects lie near the bright end of the dE luminosity function and were selected to have archival WFPC2 imaging. Mean radial velocities and velocity dispersions were determined using a pixel space χ^2 minimization scheme described in van der Marel (1994). The data were spatially rebinned to achieve a $S/N > 5$ at all radii. Velocities are measured relative to a K0III template star using the Mg b region, $\lambda\lambda 5000-5400\text{\AA}$; an analysis of the full wavelength region will be presented in a forthcoming paper. Tests show that the galaxies' internal velocity dispersions are recovered accurately down to the instrumental resolution of 23 km s^{-1} .

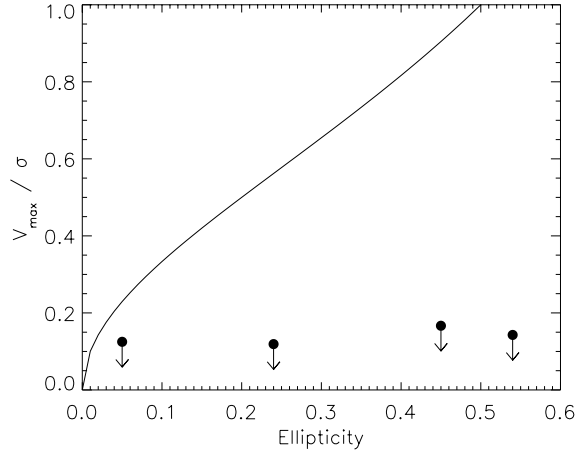


Figure 2: The ratio of the upper limit on the rotation velocity v_{\max} to observed velocity dispersion σ plotted versus mean ellipticity for four Virgo dwarf ellipticals. The solid line is the expected relation for an oblate, isotropic galaxy flattened by rotation.

3 Discussion

3.1 Anisotropic Dispersion Versus Rotational Flattening

The observed shapes and kinematics of elliptical galaxies between $-20 < M_B < -18$ are consistent with rotational flattening. This trend does not appear to extend to lower luminosity classical ellipticals and the three Local Group dwarf ellipticals (Davies *et al.* 1983; Bender & Nieto 1990). The four Virgo dEs presented here are also not rotationally flattened. For each galaxy, an average ellipticity ϵ was determined by standard ellipse fitting of archival WFPC2 V-band images between radii of $1'' - 20''$ (see Table 1). From the velocity profiles shown in Figure 1, we estimate an upper limit to the maximum rotation velocity, v_{\max} . An average velocity dispersion σ is determined for each galaxy beyond $r > 1''$ to avoid nuclear contamination.

The ratio v_{\max}/σ is plotted against ellipticity in Figure 2 and is compared to the ratio expected from an isotropic, rotationally flattened body (Binney & Tremaine 1987). The upper limits on v_{\max}/σ determined for these galaxies are 2 to 8 times smaller than expected if the observed flattenings were due to rotation. Thus, we conclude that these dEs are primarily flattened by anisotropic velocity dispersions.

3.2 Velocity Dispersion Profiles and dE Nuclei

Although the mean velocity profiles presented in Figure 1 are qualitatively similar, the velocity dispersion profiles are more heterogeneous. The velocity dispersion of the non-nucleated dE VCC 917 decreases smoothly towards the galaxy center in contrast to the three nucleated dwarfs, which vary more abruptly in the central few arcseconds. The nuclear velocity dispersions of two dE,Ns, VCC 1073 and VCC 1876, are lower than the surrounding galaxy, whereas the nuclear velocity dispersion of VCC 1254 is higher. The origin of nuclei in dEs is largely unknown, but their presence has been correlated to global galaxy parameters such as shape and specific globular cluster frequency (Ryden & Terndrup 1994; Miller *et al.* 1998). A favored hypothesis is that the nuclei are dense star clusters, possibly remnants of larger stripped or harassed objects (Moore *et al.* 1998). More work is needed to determine whether the kinematic profiles presented here are consistent with these scenarios.

Dynamical mass modeling of classical ellipticals has placed strong constraints on their origin and evolution. We are in the process of modeling these dE kinematic data using techniques similar to those described in van der Marel (1994). We will investigate the variation of M/L ratio across our sample of galaxies and as a function of galactic radius within each galaxy. In addition, we plan to study the position of these dEs in the Fundamental Plane. These results will be presented in an forthcoming paper.

References

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Table 1: Observed Virgo Cluster Dwarf Elliptical Galaxies

Galaxy Name	M_B	Type	ϵ
VCC 917	-16.4	dE6	0.54
VCC 1073	-17.3	dE3,N	0.24
VCC 1254	-16.4	dE0,N	0.05
VCC 1876	-16.8	dE5,N	0.45